Albuquerque Bernalillo County
Water Utility Authority

Technical Memo

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From: Rick Shean, Water Quality Hydrologist, Water Authority

CC: John Stomp, Chief Operating Officer, Water Authority
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Will Moats, Project Manager, NMED-HWB
Mary Lou Leonard, Director, COA-EHD
Billy Gallegos, Environmental Health Manager, COA-EHD

Date: February 18, 2014

Re: Water Authority comments on the *Fourth Quarter CY 2013 Aquifer Testing Results Bulk Fuels Facility Solid Waste Management Units ST-106 and SS-111* dated January 2014

Introduction

On behalf of the Albuquerque Bernalillo County Water Utility Authority (Water Authority), INTERA Incorporated (INTERA), reviewed the document entitled *Fourth Quarter CY 2013 Aquifer Testing Results* (January 2014) written by Shaw Environmental and Infrastructure Inc. (Shaw). This document (Shaw, 2014) was reviewed in conjunction with relevant sections from recent quarterly monitoring reports and correspondence between the New Mexico Environment Department (NMED) and Kirtland Air Force Base (KAFB).

1.0 Comment Summary for Fourth Quarter CY 2013 Aquifer Testing Results (Shaw, 2014)

In summary, a new aquifer test should be carried out on a properly developed well with observation wells sufficiently close so that drawdowns greater than the observed head variability are clearly determined. INTERA's review of Shaw's aquifer test analysis and results revealed the following:

1. Results are potentially flawed and too uncertain, making them inadequate for estimating aquifer properties that will be used as part of travel time or remediation design calculations.

2. The head variability in the observation wells during the testing period was mostly driven by barometric pressure fluctuations and other unknown factors, not by the

pumping, rendering analysis of the responses problematic. Head changes prior to the test (Figure 1) are almost as large as head variability during the test period (Figure 2), indicating that the unconfined system is very dynamic and that the stresses induced by the aquifer test are not significantly larger than pre-test variability.

3. Shaw did not adequately explain why head observations at some wells were excluded from the analysis. We recommend that Shaw immediately undertake long-term monitoring of heads using transducers and of barometric pressure to
    a. Understand head variability at the different screen depths;
    b. Quantify trends in barometric efficiency and vadose zone lag, and;
    c. Discern the cause(s) of the anomalous heads observed at wells during the aquifer test.

4. Pumping well KAFB-106157 is not developed sufficiently. INTERA's analysis of the recovery curve for the constant-rate test showed a high positive skin factor, which indicates significant reduction in the permeability of the pore space around the well screen. The skin effect was likely caused by some combination of drilling and well development. Video logging of the bore hole and biogeochemical analyses should be used to evaluate Shaw's claim that biofouling is the cause of the skin effect.

5. INTERA analyzed the recovery curve at the pumping well and drawdown curves at observation wells KAFB-10617, 10618, and 106083, deriving a higher transmissivity (T) at the pumping well and lower T values at the observation wells than Shaw. Barometric effects were removed using two methods and provided very similar results. The analysis results show that
    a. Aquifer T appears to be approximately 14,000 ft^2/d based on pumping well recovery data, but has an uncertainty of at least half an order of magnitude. However, the drawdown and recovery data from the pumping well are inconsistent, casting any estimated hydraulic parameters in doubt.
    b. Aquifer T at KAFB-10617 = 13,000 ft^2/d and storativity (S) = 0.028
    c. Aquifer T at KAFB-10618 = 11,000 ft^2/d and S = 0.033
    d. Aquifer T at KAFB-106083 = 9,200 ft^2/d and S = 0.063
    e. Drawdown estimation at the observation wells, and hence estimated transmissivities, is complicated by apparent over-recovery of the water level after pumping. Whatever caused the over-recovery might have been operating during the pumping period as well, causing an underestimation of drawdown.

6. Compensation of barometric effects might better be performed using a standard method (such as that of Rasmussen and Crawford, 1997) that allows for the incorporation of lag times.

7. The observation wells were apparently affected by other factors during the pumping test. Pumping and observation wells should be shown to be isolated from the effects of pumping at other wells, and a way of defining and compensating for the effects of other water-level trends needs to be developed.

Detailed Comments

1. Using Shaw's assumed aquifer thickness of 100 ft, INTERA's re-analysis of the aquifer test indicates hydraulic conductivity values vary between 92 and 140 ft/day.

2. Barometric correction of the observation-well data showed that barometric efficiencies were high, 0.8 to 0.9, and that the actual drawdown and recovery responses were of lower magnitude than the barometric fluctuations present in the raw data. Figures 3, 4, and 5 show the raw and corrected data for KAFB-10617, 10618, and 106083, respectively.

3. Drawdown responses on the order of 0.1 psi (0.23 ft) were seen in all three observation wells, but the water level recovered past its pre-pumping level in all wells, making the recovery data uninterpretable and casting doubt on the estimation of drawdown.

4. Horner (1951) analysis (essentially a Jacob semilog method with a superposition time function to account for changes in the pumping rate) of the pumping well recovery (Figure 6) indicated a T on the order of 14,000 ft^2/d and a high positive skin. However, the model that produced the Horner match to the recovery data could not approximate the drawdown data at all (Figure 7), indicating significant inconsistency between the drawdown and recovery data. (Note that the data in these two plots are offset by 27.55 psi to represent the pressure at the base of the aquifer.)

5. Simulation of the drawdown data from the observation wells KAFB-10617, 10618, and 106083 (Figures 8, 9, and 10, respectively) provided estimated T values ranging from 9,200 to 13,000 ft^2/d and S values ranging from 0.028 to 0.063. The over-recovery after pumping cannot be matched at all. If the cause of the over-recovery also affected the drawdown data, drawdown might have been higher, and estimated T lower, than is shown.

References

Horner, D.R. 1951. "Pressure Build-Up in Wells," *Proceedings of the Third World Petroleum Congress, The Hague, Netherlands, May 29, 1951*. Leiden, The Netherlands: E.J. Brill. Sec. II, 503-523. Reprinted 1967. *Pressure Analysis Methods*. AIME Reprint Series Vol. 9. Richardson, TX: Society of Petroleum Engineers. 45-50.

Rasmussen, T.C., and L.A. Crawford. 1997. “Identifying and Removing Barometric Pressure Effects in Confined and Unconfined Aquifers,” Ground Water, 35(3): 502-511.

Shaw, 2014. Fourth Quarter CY 2013 Aquifer Testing Results Bulk Fuels Facility Solid Waste Management Units ST-106 and SS-111. Prepared for U.S. Army Corps of Engineers, Albuquerque District, Albuquerque, NM 87109 by Shaw Environmental & Infrastructure, Centennial, CO 80112.

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Figure 1. Drawdown Variability Prior to the Aquifer Test

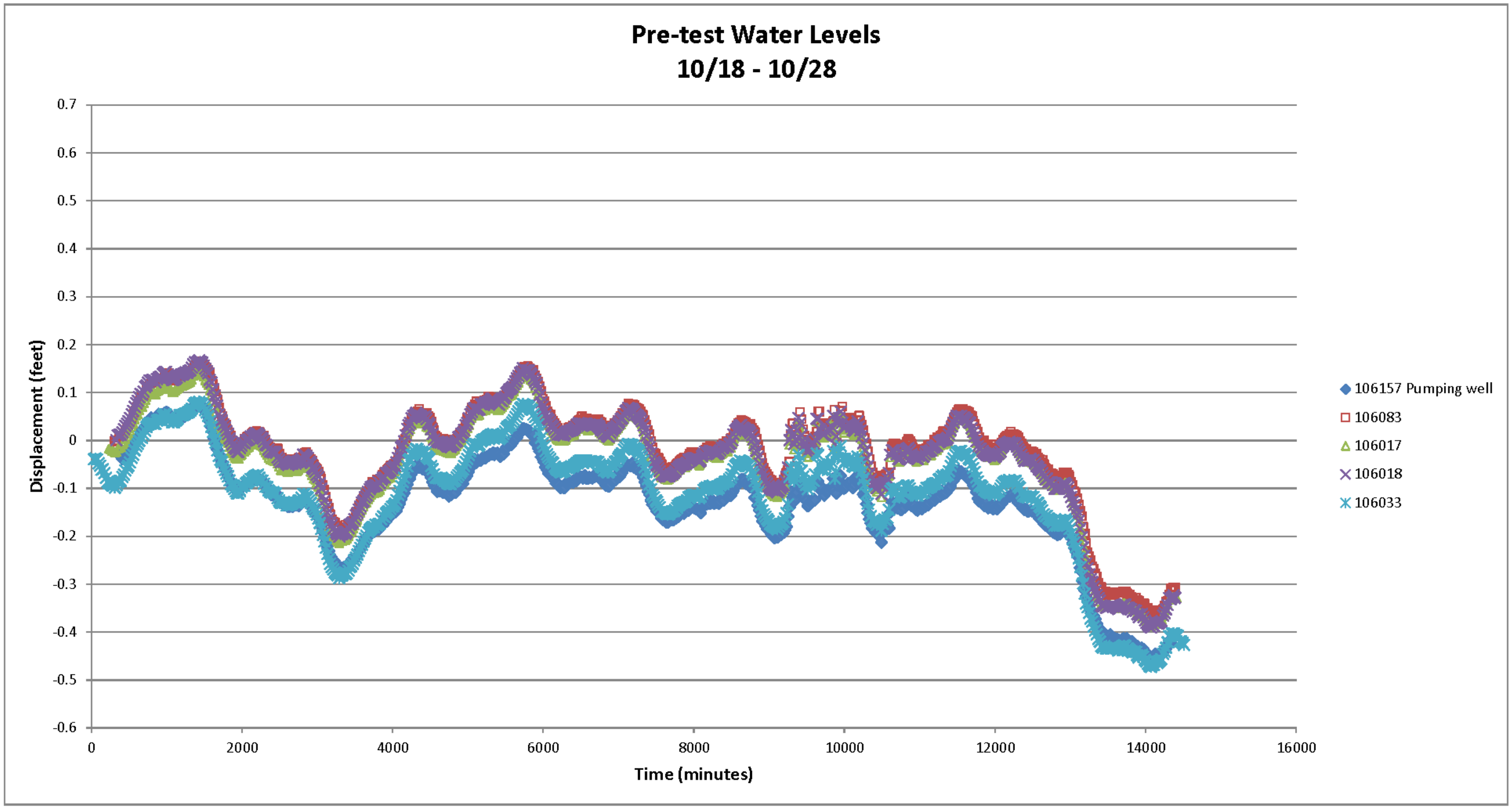

Figure 2. Water-Level Displacement in Observation Wells During Pumping Test.

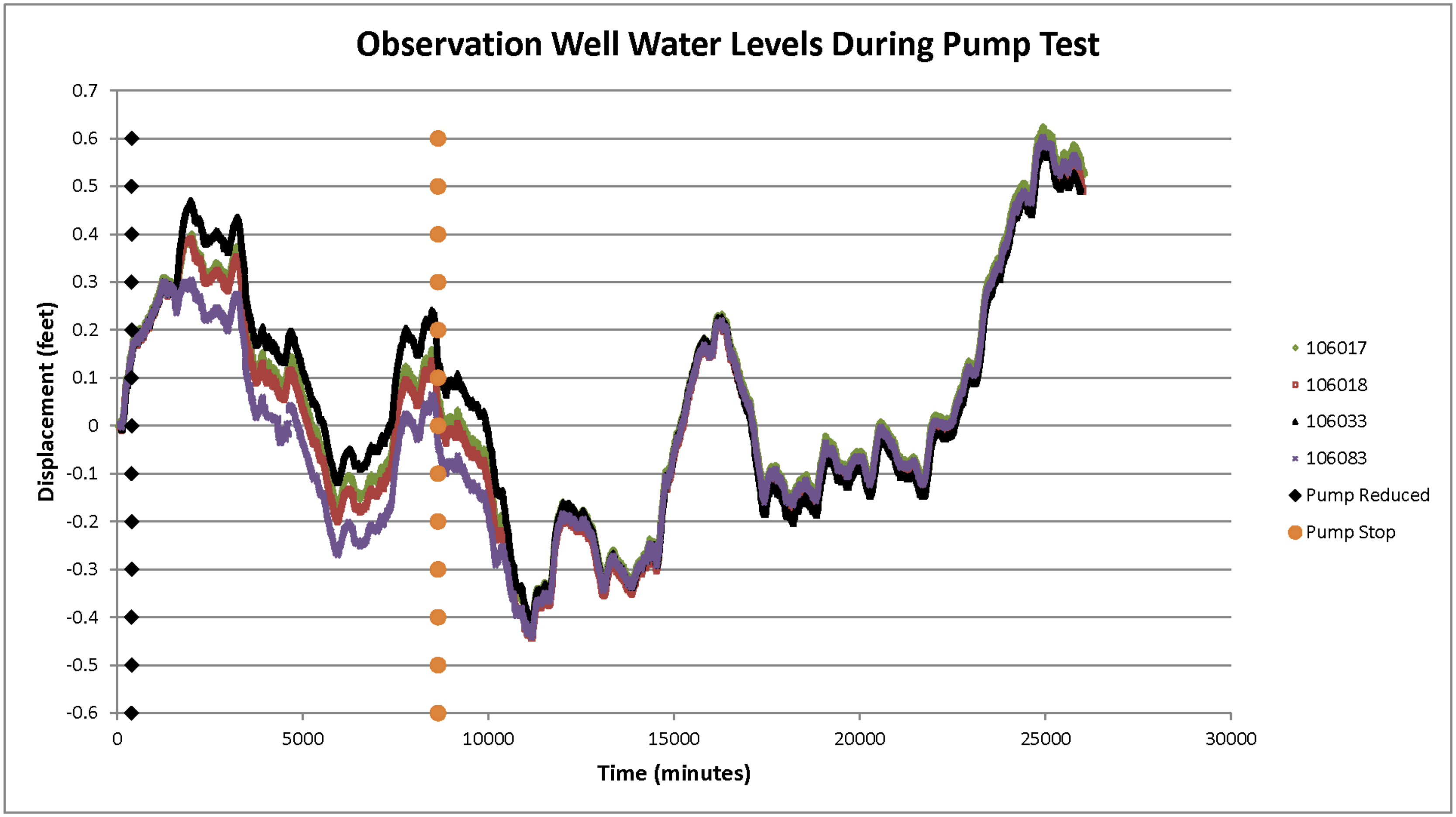

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Figure 3. Measured Pressure and Barometric Correction for Observation Well KAFB-10617

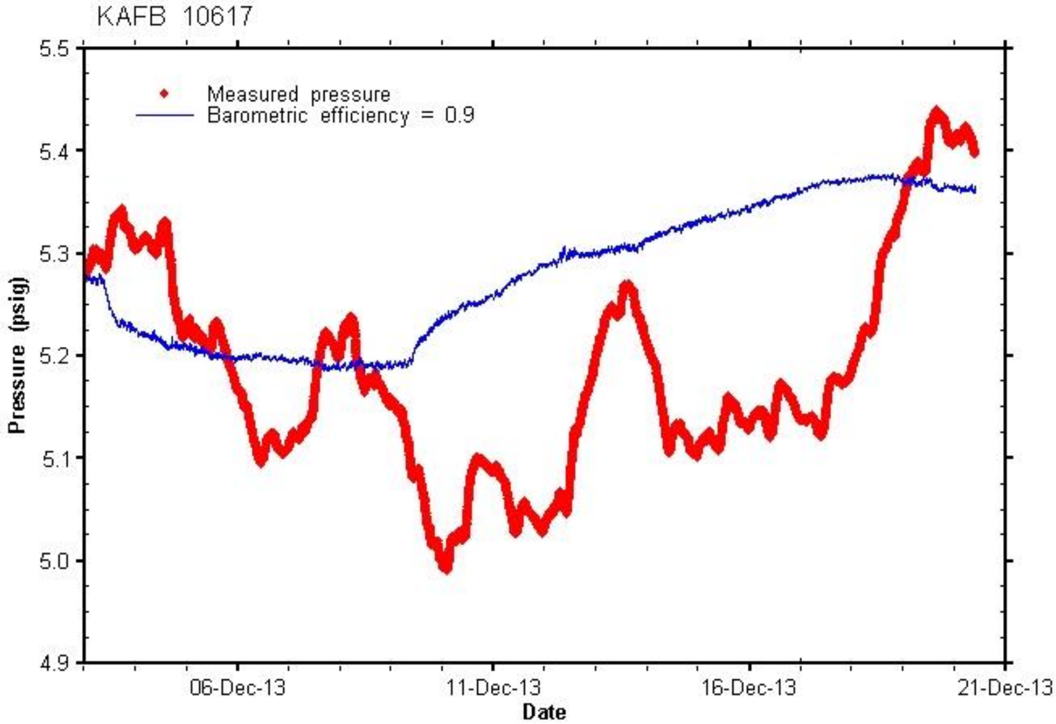

Figure 4. Measured Pressure and Barometric Correction for Observation Well KAFB-10618

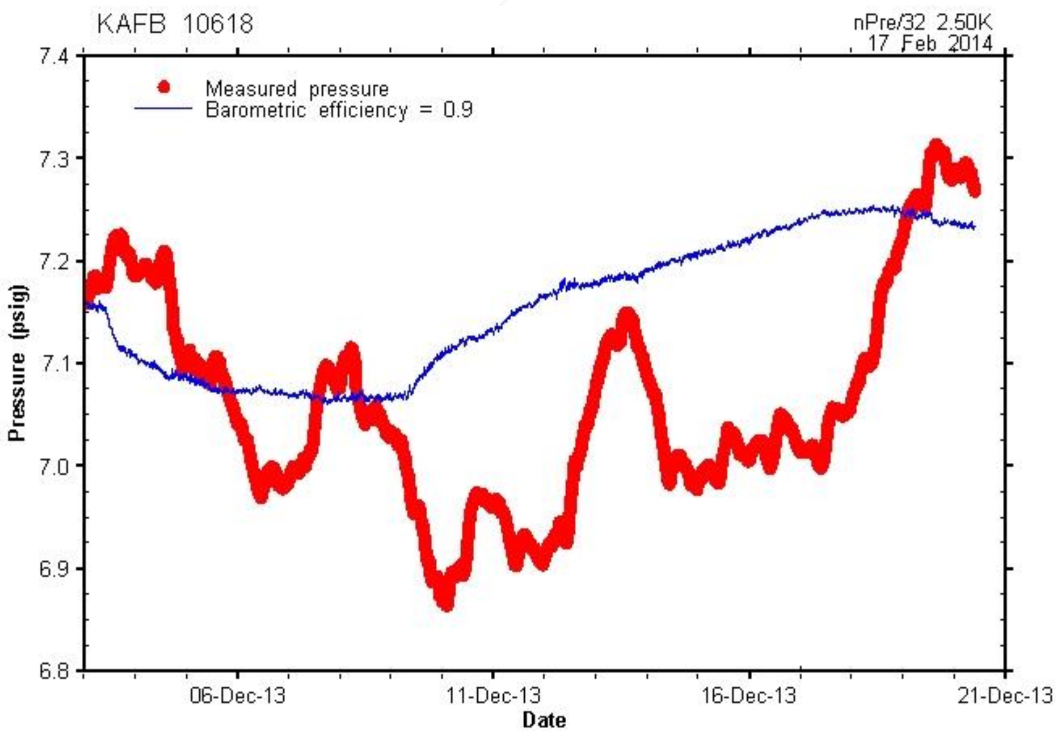

Figure 5. Measured Pressure and Barometric Correction for Observation Well KAFB-106083

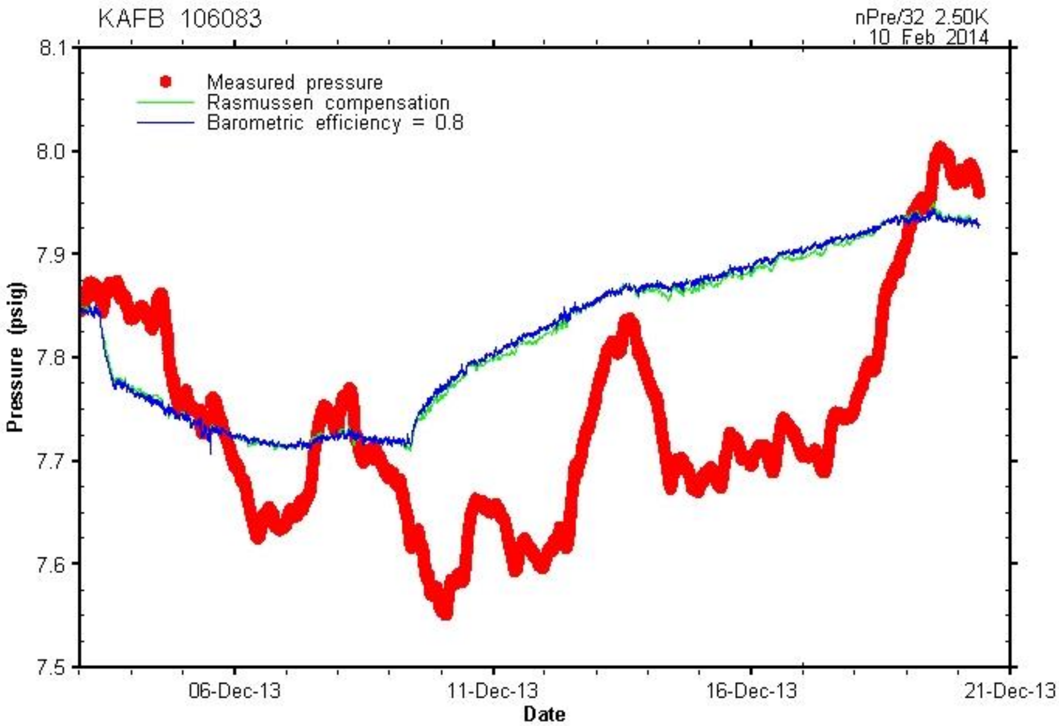

Figure 6. INTERA's Horner Analysis of the Pumping Well Recovery Data

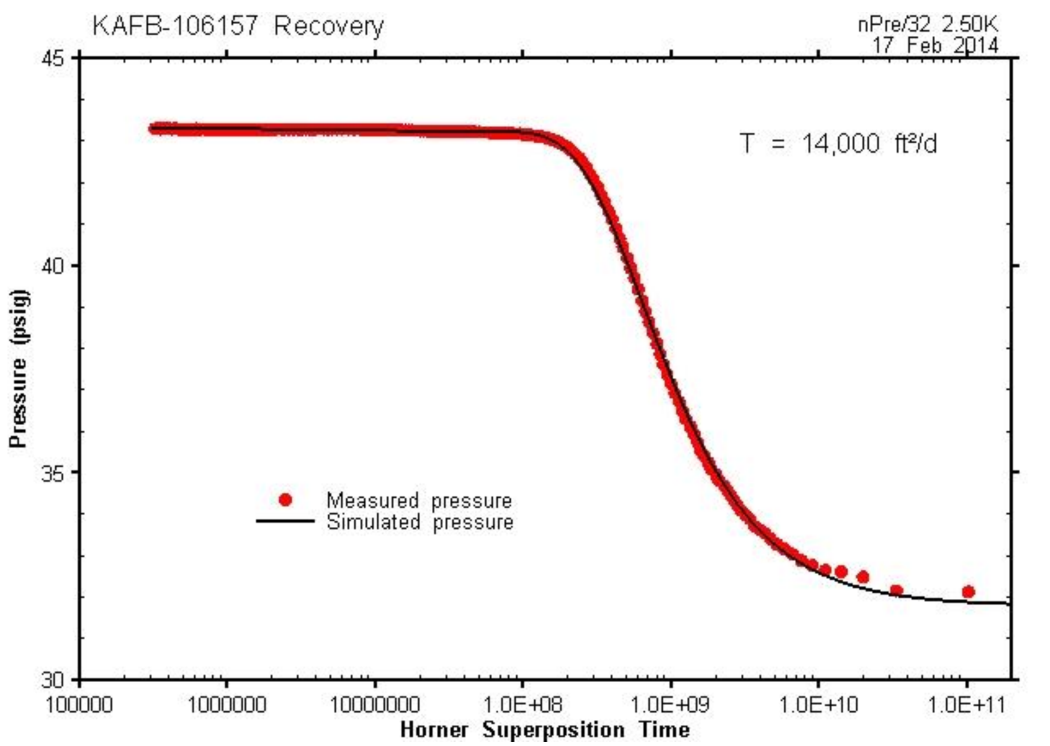

Figure 7. Cartesian Plot Showing That the Simulation That Matches the Recovery Data Does Not Match the Drawdown Data

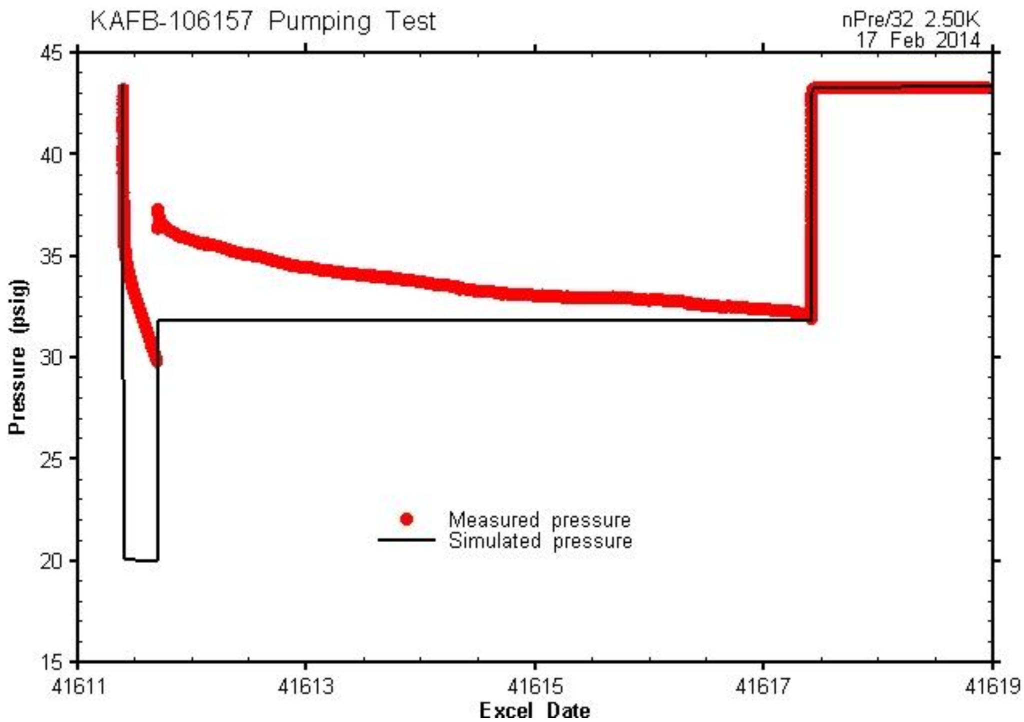

Figure 8. INTERA's Analysis of the KAFB-10617 Drawdown Data

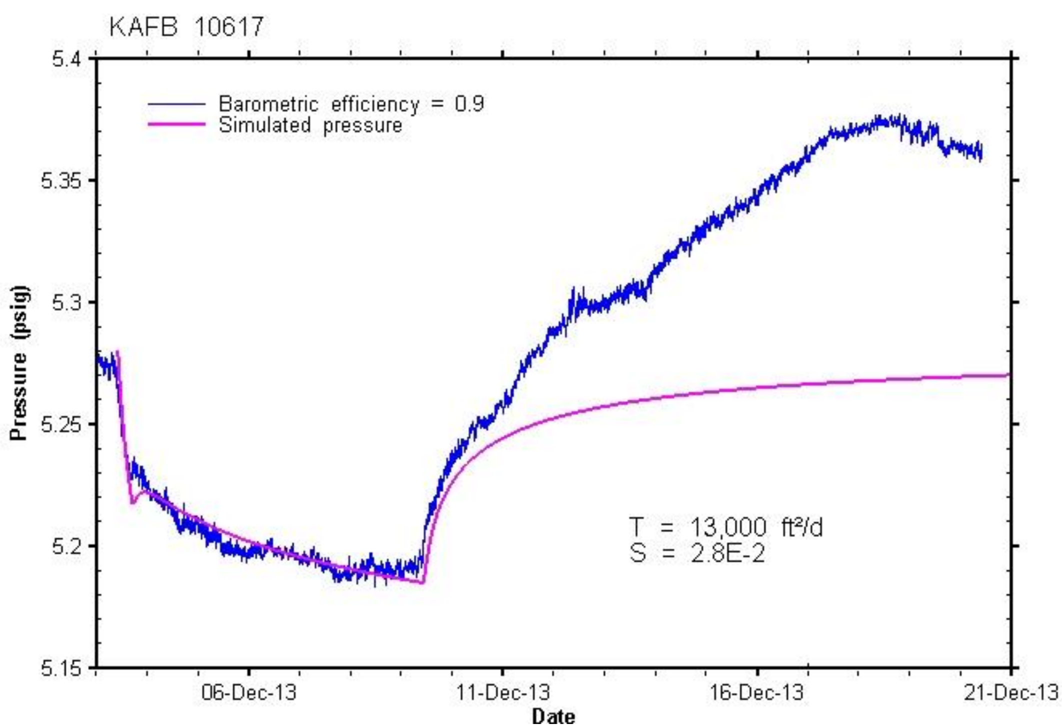

Figure 9. INTERA's Analysis of the KAFB-10618 Drawdown Data

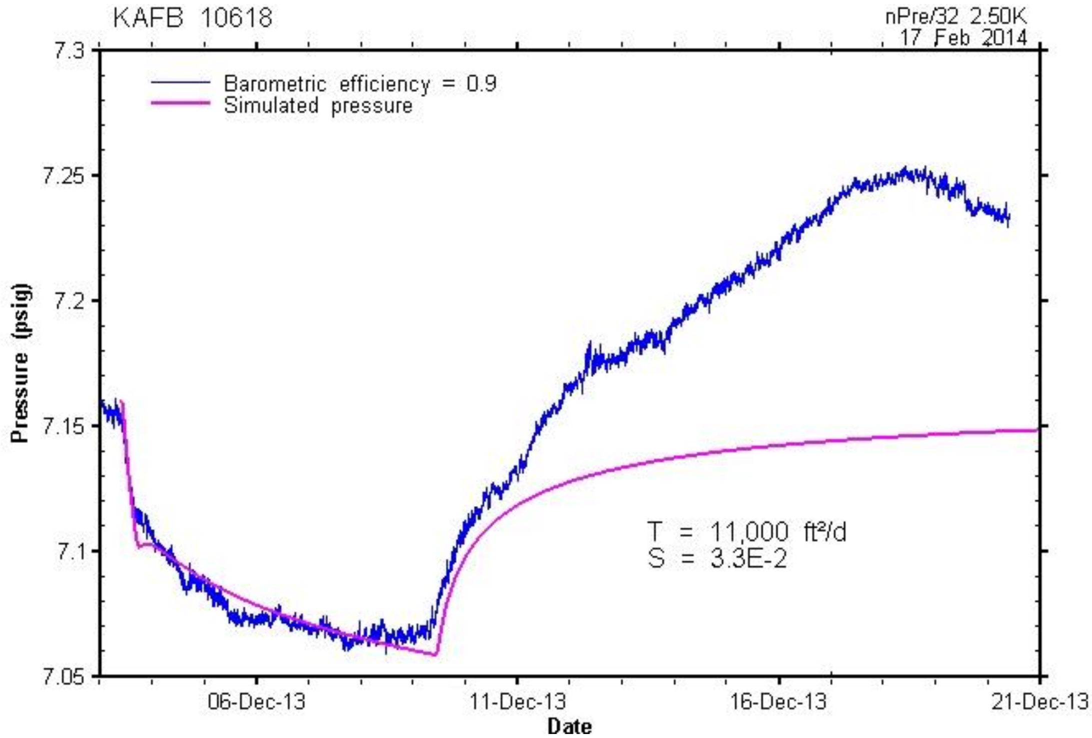

Figure 10. INTERA's Analysis of the KAFB-106083 Drawdown Data